



# Pick the Right Pump

CHOOSING A CIRCULATOR FOR  
SOLAR HOT WATER SYSTEMS

by Chuck Marken

Some things—the coldest beer or the biggest slice of pizza—are easy to pick, but selecting the right pump for a solar hot water (SHW) system isn't that simple. Pump choices are numerous—DC or AC powered; bronze, stainless steel, iron, or plastic; high, medium, or low head. But picking the right pump doesn't have to be a painful experience. Here's some sound advice on how to best match a pump to your SHW system for years of trouble-free service and high performance.

## Low-Head Pumps



Grundfos 15-18 SU pump. The "S" stands for stainless steel and the "U" is for union (union set shown, extra cost).



EI-Sid 10 PV, DC pump. Although it may run on a 10-watt PV module, this pump is usually coupled with a 20-watt module to make sure it starts in all applications.

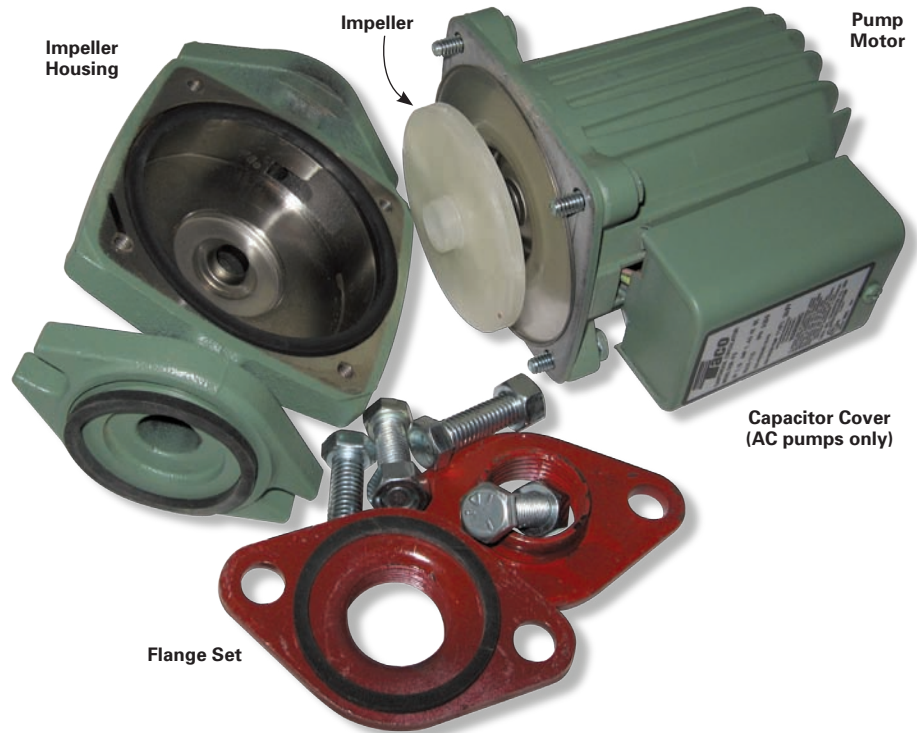
Pumps used in solar heating systems are called hot water circulators. They move fluid through the solar collectors and/or heat exchanger to where the heated fluid can be stored or used. A circulation pump is made up of a motor, impeller, and impeller housing. The motor spins the impeller in the housing and, through centrifugal force, moves liquid through a plumbing circuit.

Circulation pumps must be primed or wet when they start, as they are not designed to suck liquid into the impeller. Unlike positive-displacement pumps, which can lift a fluid from below the pump, circulation pumps must have the impeller housing filled with the circulating fluid at all times. They are used in closed plumbing loops that are always entirely filled, or in systems with the pump situated lower than a tank's water level.

Common circulation pumps have maximum service temperatures of about 140°F, but almost all hot water circulators are rated above 200°F. Hot water circulators are a must for virtually all active-type solar water heating systems.

Selecting a pump is not difficult—your solar hot water system design will dictate which pumps are suitable, with alternatives falling into three application criteria:

- Pump material
- Pump head and flow rate
- Power source



Typical flange pump pieces.

## The Right Materials

Oxygen is good for us, but bad for iron pumps. Oxygen creates a corrosion problem in cast iron pumps, just as steel or iron rusts (oxidizes) when exposed to water and air. The less expensive circulation pumps are made with an iron impeller housing. They are usable in closed-loop systems where little or no oxygenated water exists.

But in open and potable water loops, an iron pump will corrode, impeding the flow or stopping it completely, often within a few months. Domestic hot water loops need pumps with a bronze, stainless steel, or plastic impeller housing and impeller. These corrosion-resistant materials are also recommended for any drainback system that does not use distilled water as the collector loop fluid.

The most common domestic hot water (DHW) pumps are bronze or stainless steel but plastic housing DHW pumps also can last for decades. The cost of bronze pumps has increased quite a bit in the last few years with the increase in copper prices. This has made stainless steel pumps more attractive.

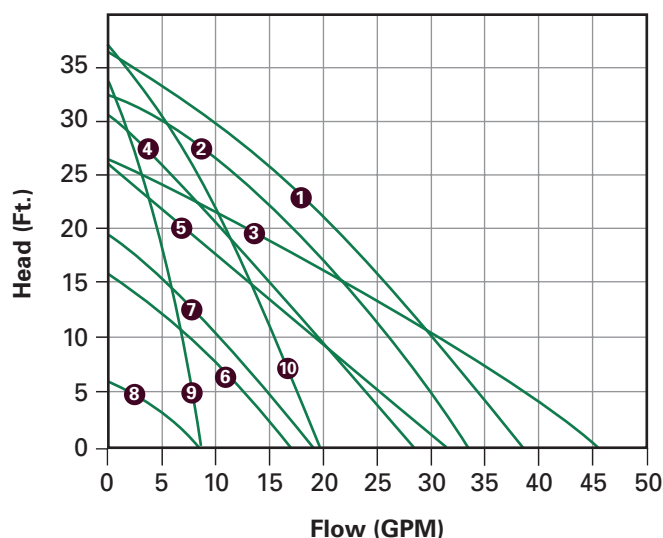
## Head & Flow

Depending on their application, pumps must overcome two different types of head—atmospheric and friction. Atmospheric head is the difference in height between the natural level of the liquid when the pump is off, and the height to which the pump needs to push the liquid when the system is operating. The pump must develop enough pressure to push the circulating fluid to the top of the loop or, in the case of a drainback solar water heater, to the top of the collectors. If the pump falls short,



Taco 006-B4, domestic hot water pump. Note the 3/4-inch copper solder connections.

## Grundfos AC Pump Performance Curves



1 UP 26-116 F; 2 UP 26-99 F; 3 UP 43-75 F/UP 50-75 F; 4 UP 26-96 F;  
5 UP 26-64 F; 6 UP 15-42 F BRUTE II; 7 UPS 15-58F/FC (Spd 3);  
8 UP 15-10 F/FR; 9 UP 15-100 F; 10 UP 26-120 U

the system will not function. Pumps in a plumbing circuit that always remains full of liquid do not need to overcome any atmospheric head. These kinds of loops include closed-loop antifreeze and direct-pump open systems.

Friction-head loss is the resistance to flow due to the circulating fluid's contact with the pipe walls. Frictional head increases with smaller pipe diameter, increased length, changes in direction (like elbows, etc.), and increased flow. Given the details of those factors, frictional head loss can be accurately calculated. But normally, those factors are not significant enough to bother calculating in small solar

## Installation Notes

✓ You can put two pumps in series to double the total head pumped. But beware: Using series or stacked pumps to achieve the head required in some drainback systems can cause big problems. If one pump quits during colder months (and they all quit eventually), and the other keeps pumping, it could lift the water just high enough to where it can sit and freeze. The frozen pipe can burst, and then the system could pump all the water in its drainback tank into the attic. This is one reason for the less-than-stellar reputation of drainback systems in some parts of the United States. The solutions to this head problem are to raise the drainback tank to a level that will accommodate the head of the chosen pump (see how James Dontje solved this in his article in *HP120*) or to select a higher-head pump if available.

✓ Many new pump installations will need a flange set or union set to connect the pump to the piping system. Make sure you have the additional parts you need before you start work on the system.

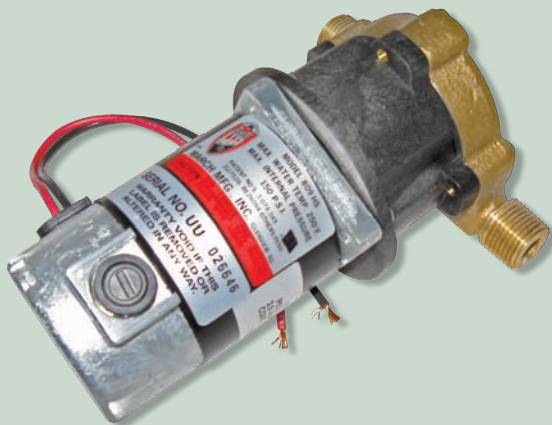
✓ Installing two pumps in a parallel piping arrangement will increase the flow of the circulating fluid, but will not increase the total head.

✓ All the SHW pumps mentioned in this article are classified as "fractional horsepower" and don't require a separate electrical circuit. However, fractional hp pumps do require a disconnect—an appropriately rated switch or breaker or a UL-approved cord and plug connection.

heating systems—except in rare circumstances such as very long piping runs (100 feet or more) with small tubing.

The flow rate through solar collectors should meet the manufacturers' specifications, but there is a good deal of fudge

## Medium-Head Pumps



The March 809-HS magnetic drive, bronze DC pump needs a 50-watt module to pump to its rated 15-foot head. The magnetic drive tends to be noisier than other types of pumps.



A Grundfos 15-42 iron pump suitable for most small- and medium-sized antifreeze-type solar water heaters (shown with pump flange set).



## Solar Pump Specifications

AC Pumps	Volts	Watts	Head Category	Cutoff Head (Ft.)	Gpm at Head	Pump Material	Suitable Applications	Price
Taco 009F	120	168	High	34.00	5 at 20 ft.	Iron	Drainback or large antifreeze systems	\$255
Taco 009B	120	168	High	34.00	5 at 20 ft.	Bronze	Drainback systems	420
Grundfos 26-96 F	120	205	High	30.00	15 at 14 ft.	Iron	Drainback or large antifreeze systems	297
Grundfos 26-96 BF	120	205	High	30.00	15 at 14 ft.	Bronze	Drainback or large antifreeze systems	325
Taco 011F	120	211	High	30.00	15 at 18 ft.	Iron	Drainback or large antifreeze systems	273
Grundfos 15-42 F	120	85	Medium	16.00	10 at 9 ft.	Iron	Drainback or large antifreeze systems	108
Taco 008F	120	95	Medium	16.00	10 at 8 ft.	Iron	Drainback or large antifreeze systems	158
Taco 008B	120	95	Medium	16.00	10 at 8 ft.	Bronze	Drainback systems	319
Taco 006B	120	62	Low	8.00	5 at 5 ft.	Bronze	DHW <sup>b</sup> systems	179
Grundfos 15-18 SU	120	85	Low	7.00	5 at 5 ft.	Stainless	DHW <sup>b</sup> systems	179

### DC Pumps

March 809-BR-HS, 12 VDC	12	50	Medium	15.50	4 at 8 ft.	Bronze	Drainbacks or large antifreeze systems	\$228
March 809-BR, 12 VDC	12	20	Low	7.00	3 at 3 ft.	Bronze	DHW <sup>b</sup> systems	200
El-Sid 20 PV-direct	12	20 <sup>a</sup>	Low	4.17	3 at 42 in.	Bronze	DHW <sup>b</sup> or small antifreeze systems	334
El-Sid 10B12	12	10	Low	3.33	2 at 35 in.	Bronze	DHW <sup>b</sup> or hydronic heating systems	242
El-Sid 10 PV-direct	12	10 <sup>a</sup>	Low	3.33	2 at 35 in.	Bronze	DHW or small antifreeze systems	245

Note: The El-Sid warranty only covers pumps to temperatures up to 175°F, which could be a problem in collector loops that experience higher temperatures.

<sup>a</sup>Double the PV wattage when not using water as a heat-transfer fluid; in some cases, even circulating water will require a larger PV module to start the pump reliably. <sup>b</sup>Potable water

factor here. Solar collector loops will operate efficiently over a wide range of flow rates, but choosing too large a pump can cost more up-front and will use more energy. And an undersized pump without sufficient head in a drainback system is a disaster—the system just won't work. Collector manufacturers' recommended flow rates are usually published in their literature. If not, you can find this information in the OG-100 ratings directory (see Access).

A pump's performance under various conditions is shown by its "pump curve." This performance curve is typically presented as a graph or a table, with selected flow rates given at different pump pressures. The pressure a pump exerts is usually expressed in feet (sometimes decimeters) of head. Feet of head is a more useful way of expressing the pressure in real-world circumstances and is used in most pump curves. It can also be expressed in pounds per square inch (psi), where 1 psi equals 2.31 feet of head. In graph form, the head is the vertical axis and the flow is the horizontal axis. As you can see in the example graph (opposite page), as the head decreases, the flow increases.

## High-Head Pumps



A Taco 009F high-head iron pump, suitable for most drainback and larger antifreeze systems.

### AC or DC?

One of your final considerations for choosing a pump depends on whether you're planning to use AC or DC to power it. Both kinds of pumps are available, but the range of available DC pumps is much narrower than for AC. AC pumps have an unlimited energy supply if they are powered by a reliable utility grid. DC pumps can be run directly by a PV module and make a solar water heating system independent of the grid.

One way to approach the DC and AC pump choice is to examine relative system efficiencies. The efficiency of some heating systems is rated by the relationship of the amount of energy output to the energy input. If you have a system that produces a certain amount of heat with half the equivalent electrical input, the "coefficient of performance" (COP) is 2. Produce four times as much hot water as the amount of energy input from electricity and the COP is 4. We can use this same methodology in evaluating the efficiency of SHW pumps.

Using a utility-powered AC pump for your solar water heating system will give you a COP between 12 and 25, and this is an excellent value compared to electric water heaters, which have a COP of 1. But the COP will never be as good as a DC PV-powered SHW system. DC hot water circulation pumps can have a higher COP than AC pumps because there is no traditional energy input if a PV module powers the system. If you use a solar-electric module to power the pump, your COP is infinite—you're not adding *any* input energy. The sun provides it all, and you get something for nothing after the initial investment. PV-powered systems are also immune to utility outages. This is a big plus with antifreeze systems, since the collectors can overheat on sunny days if the pump stops operating due to a power failure. An overheated collector can actuate the pressure-relief valve, which will make it necessary to recharge the system with antifreeze solution. In some cases, the overheating can be so severe that the antifreeze solution will be compromised to the point of needing replacement.

Although it seems like a no-brainer to go with a DC PV-direct power source for your solar water heater pump—not so fast. A few other factors can influence your decision about the power source:

- Some DC pumps are noisier than AC pumps, which can make an installer think twice about the placement of a DC pump.
- High-head drainback DC pumps are few and far between. Finding a reliable high-head DC hot water circulator is impossible at this time, limiting the head of a DC drainback system to about 15 feet.
- Any given PV module and SHW collector are rarely a perfect match. The PV module often will “outproduce” the collector and the pump may run early in the morning or late in the afternoon when the collector isn't producing useful heat. The result? Unwanted pump operation can actually cool the water in the solar storage tank. Until recently, no DC-powered differential controllers were available to limit this unwanted pump operation. Art Tec (see Access) recently began manufacturing a DC differential controller that optimizes pump run-time in PV-direct SHW systems.

AC hot water circulators are firmly entrenched in normal distribution in the United States and are therefore less expensive and easier to procure. A DC pump will cost more than an AC pump of the same head and category, and the PV module will add to the cost—but if it fits into your design and budget, the extra cost is well worth the expense. PV-powered DC pumps are normally the optimal choice for a solar heating system except in high-head drainback and very large antifreeze systems.

## The Fine Print

Knowing how to decipher the fine print on the pump can give you valuable insight into whether or not it'll be a good match for your SHW system. For example, the “15-18 SU” model number of a Grundfos pump tells you that the impeller housing inlet is

15 millimeters and the maximum head is 18 decimeters; “S” is for stainless steel, and “U” is for union attachment.

Other manufacturers have model numbers that may also denote the power consumed or the pump construction. An “F” in a model name usually denotes a flange iron pump, which can make the pump housing easily removed and replaced. “B” stands for bronze, so a “BF” would be a bronze flange pump. Look at the Solar Pump table (previous page) to see some of the relationships between model numbers and specifications.

## Common Pumps

Several pumps and manufacturers are listed in the table and Access. The models listed were included because they are readily available and most folks in the solar industry are familiar with them, but there are also others on the market. One very important point: Make sure any circulation pump you consider for a SHW system is intended for hot water—at least 200°F for most systems.

Besides that, knowing a few simple rules and the manufacturer's pump specifications is all you need to make an intelligent choice, whatever your needs. After almost thirty years installing and servicing solar hot water circulation pumps, almost all the models I've used seem very durable and long lasting. So pick your pump(s) and get into some really hot water.

## Access

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Art Tec • 866-427-8832 • [www.arttec.net](http://www.arttec.net) • DC differential temperature controller

Solar Rating and Certification Corp. • [www.solar-rating.org](http://www.solar-rating.org) • OG-100 ratings directory

### Pump Manufacturers:

Bell & Gossett • 847-966-3700 • [www.bellgossett.com](http://www.bellgossett.com)

Grundfos Pumps Corp. • 913-227-3400 • [www.grundfos.com](http://www.grundfos.com)

Ivan Labs • 561-747-5354 • El-Sid pumps

March Manufacturing Inc. • 847-729-5300 • [www.marchpump.com](http://www.marchpump.com)

S. A. Armstrong Ltd. • 416-755-2291 • [www.armstrongpumps.com](http://www.armstrongpumps.com)

Taco Inc. • 401-942-8000 • [www.taco-hvac.com](http://www.taco-hvac.com)

